MERG Report 2002-1

Experimental Reclamation Project
Shrub Trial Plots - Brewery Creek Mine

By Stu Withers

MERG is a cooperative working group made up of the Federal and Yukon Governments, Yukon First Nations, mining companies, and non-government organizations for the promotion of research into mining and environmental issues in Yukon.

10C-11

103-05910/

Experimental Reclamation Project

Shrub Trial Plots - Brewery Creek Mine

submitted to

Mining Environment Research Group
and
Viceroy Minerals Corporation

Stu Withers

March 2002

Experimental Reclamation Project

Shrub Trial Plots – Brewery Creek Mine

Non-technical Summary

In the September 2000, eleven shrub species were planted in experimental plots at three different areas of the Brewery Creek Gold Mine near the Klondike River. All of these shrub species naturally grow in the mine area. The purpose of this project is to find out which of these shrub species may be useful for revegetating the large open areas at the mine site, after the mine closes. It is anticipated that this information will also be useful when revegetating other mine sites in the Yukon.

The three sites chosen for these experiments are a steep north-facing slope, a steep south-facing slope, and a lower, nearly level area. The shrubs were planted in six plots at each of the three sites. All three areas had been graded and seeded in 1996-97, and there was a fairly thick growth of grasses and clovers at the time the shrubs were planted. To determine if this thick growth interfered with the survival of the newly planted shrubs, the grass and clover was first removed from one half of each plot.

The shrubs used in these experiments were transplanted from the nearby forest. Willow stem cuttings were also planted, and at one site, aspen root cuttings were tried. At all three sites, black spruce seeds were planted.

In July 2001, these test plots were checked to see which shrub species were still growing. At each plot, the number of surviving shrubs was counted. It was found that most of the shrub transplants were growing well, but many of the willow stem cuttings had not survived. The black spruce grown from seeds were not seen until another visit to the site in late August. The largest concentration of black spruce seedlings were found on the north-facing slope. Black spruce are well suited to north slopes and other cold areas.

It was also found that several shrub species were growing better on areas where the grass and clover had first been removed.

In order to get a better idea which of these shrub species are suitable for revegetating mine sites, these test plots should be checked again in future years.

Acknowledgements

The following people were instrumental in the implementation of this project:

Larry Connell, Mike Samuels, Steve Johnson, Strider Lacosse and John Waters of Viceroy Minerals Corporation provided logistical support and field assistance at the Brewery Creek Mine.

Don White of DIAND Forest Resources supplied the black spruce seeds.

Bonnie Burns of Laberge Environmental Services participated in the field surveys, the establishment of the trial plots, and the follow-up monitoring surveys.

Tony Hill, Catherine Kennedy and Chuck Hubert of the Yukon Department of Renewable Resources critically reviewed the draft report.

The project was administered by Karen Pelletier and Paula Sauve of Mining Land Use, DIAND, and by Lori Walton of the Yukon Department of Economic Development.

The project was funded by the Mining Environment Research Group and by Viceroy Minerals Corporation.

Contents

Non-technical Summary		2
Acknowledgements		3
1.0	Background	5
2.0	Methods	7
	2.1 Site Selection and Baseline Data Collection	7
	2.2 Establishment of Trial Plots	7
	2.3 Follow-up Monitoring	9
3.0	2000 Shrub Propagation Trials	9
4.0	2001 Results and Analysis	15
	4.1 2001 Monitoring Results	15
	4.2 Preliminary Analysis	17
5.0	Recommendations	19
References		20
Appendix A: Photographs		21

1.0 Background

The reclamation of large open disturbed areas often requires assisted revegetation efforts for the expedient recovery of these surfaces to their natural state. Large open areas are usually too far from local seed sources for natural revegetation to quickly occur. An initial vegetative ground cover can readily be established through the seeding of agronomic and native varieties of grasses and legumes. Later successional stages can be encouraged through the establishment of shrub stands at strategic locations on these large disturbed surfaces.

Information on the reclamation capabilities of shrub species that are commonly found in the Yukon has largely been taken from the results of field trials in other northern regions (primarily Alaska and northern Alberta). In order to fully appreciate the potential of shrub species for revegetating mine sites in local environments, there is a requirement for field testing of these species at Yukon mine sites.

Viceroy Minerals Corporation has been implementing a multi-year reclamation program at the Brewery Creek Mine near the Klondike River (Figure 1) since the commencement of mine development in 1994. Waste rock dumps and backfilled pits have been recontoured and revegetated using a variety of seed and fertilizer mixes, including specially formulated northern native seed mixes. In addition, limited experimentation with the establishment of shrubs on the reclaimed surfaces has been carried out. In the spring of 1998, willow cuttings were collected from the Dawson City area and planted in trial plots in the reclaimed Canadian Zone waste rock storage area by students from the Robert Service School. Viceroy Minerals Corporation has monitored these plots on a regular basis.

In this project, funded jointly by the Mining Environment Research Group and Viceroy Minerals Corporation, shrub propagation experimental plots were established at the Brewery Creek Mine in the fall of 2000 with the objective of determining the reclamation potential of locally occurring species.

Figure 1: Location of Brewery Creek Mine

2.0 Methods

The 2000 and 2001 field seasons included the completion of the following work at the Brewery Creek Mine:

2.1 Site Selection and Baseline Data Collection

A preliminary survey of the Brewery Creek Mine in July 2000 resulted in the selection of three sites for shrub propagation trials (Figure 2). Sites were selected to represent a range of ecological variables (elevation, slope and aspect). All three sites had already been seeded with a cover of grasses and legumes.

At each site, baseline data was collected, including topographical information (elevation, slope and aspect), soil physical properties (texture, drainage and compaction), soil pH and existing vegetation (see photographs – Appendix A).

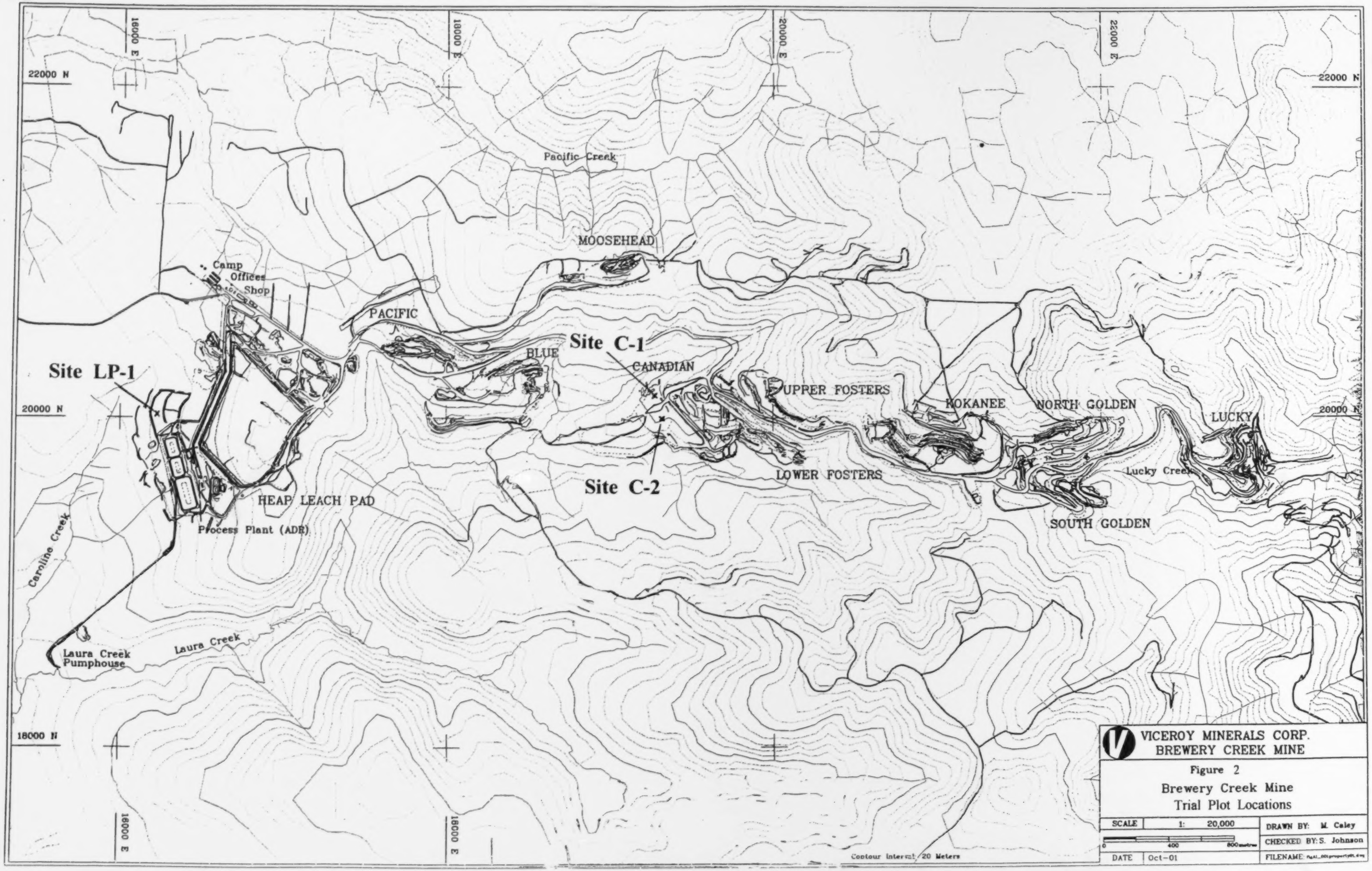
Soil samples were not collected for nutrient analysis during the current survey, although a 1996 analysis of plant-available nutrients in the Canadian Zone waste dump showed nitrate and sulfate levels to be low while phosphorous and potassium levels were moderate.

An inventory was also taken of the shrub species colonizing disturbed areas near each site. This information on voluntary revegetation was used for selecting species for propagation trials.

2.2 Establishment of Trial Plots

Test plots were established at the three sites in mid-September 2000, at the onset of seasonal dormancy (leaves had turned colour but had not yet fallen). At each location, six two-metre X three-metre plots were situated abutting each other in a line perpendicular to the slope.

Existing vegetation was removed from one half of each plot but was retained on the other half. Shrubs (transplants, stem cuttings and root cuttings) were collected from nearby disturbed areas and planted in the test plots, with the number of specimens



VICEROY MINERALS CORP.
BREWERY CREEK MINE

Figure 2

Brewery Creek Mine
Trial Plot Locations

SCALE	1: 20,000	DRAWN BY: M. Caley
0 400 800 metres		CHECKED BY: S. Johnson
DATE	Oct-01	FILENAME:

placed in each half of each plot recorded (see photographs – Appendix A). Rooting hormone (beta-indolyl-butyric acid) was applied to the semi-hardwood (previous season's growth only) willow stem cuttings and aspen root cuttings. A small amount of soil was transported with each transplant to the test plots in order to transfer mycorrhizal fungi. Black spruce seeds, provided by Forest Resources (DIAND), were sown in one plot at each test site. Bone meal (2% total nitrogen, 14% phosphoric acid and 27% calcium) was applied to all plots at test site LP-1. No other fertilizer was used.

Comparison plots were also established in undisturbed, forested areas nearby each test site. Five-metre X five-metre plots were situated in areas representing natural, pre-disturbance conditions. At each comparison plot, the percent cover for each species in the tree, shrub and ground cover layers was estimated and recorded.

2.3 Follow-up Monitoring

The shrub propagation trials plots were monitored in early July 2001. At each plot, the number of surviving plant species were recorded. The plots were revisited in late August 2001. Photographs of plots were taken during both 2001 site visits (see Appendix A).

3.0 2000 Shrub Propagation Trials

Following is a summary of the site conditions, reclamation history and existing vegetation at each of the three test sites, along with a description of the test plots and the shrub species used for propagation trials:

Site C-1 (Canadian Zone)

UTM Coordinates:	0634817 W 7105637 N
Elevation:	828 m
Slope:	30 ^{0}
Aspect:	northwest
Soil Characteristics:	well-drained (moist at time of planting because of recent rains), angular bedrock fragments with clay (largest particle 40 cm), pH 7.0

Reclamation History:
This area was recontoured, seeded and fertilized on October 8, 1997 with 75 kg/ha Brewery Creek seed mix and 300 kg/ha fertilizer (28-28-0). Seed and fertilizer were dispersed by a bulk mixer truck.

Brewery Creek seed mix included:

17% Fowl Bluegrass
16% Dalhurian Wild Rye
16% Sheep Fescue
16% Nugget Kentucky Bluegrass
12% Creeping Red Fescue
10% Climax Timothy
8% Noducoat Alsike Clover
5% Rangeland Alfalfa

Current Vegetation: In area of trial plot (seeded area)

shrubs — *Populus tremuloides*

forbs — *Achillea millefolium*
Chenopodium album
Medicago sativa
Plantago major
Trifolium hybridum

graminoids — *Elymus trachycaulus* ssp. *subsecundus*
Festuca ovina
Phleum pratense
Poa palustris

Total vegetation cover: 30 %

Colonizing lower slopes near edge of clearing

shrubs — *Betula neoalaskana*
Ledum groenlanicum
Picea mariana
Populus tremuloides
Rosa acicularis
Rubus idaeus
Salix alaxensis
Salix bebbiana
Salix glauca
Shepherdia canadensis
Spiraea beauverdiana

forbs — *Cornus canadenis*

graminoids — *Calamagrostis canadensis*
Luzula parviflora

Shrub species used in reclamation trials:

Plot A — Alaska birch (*Betula neoalaskana*) transplants
15 in cleared area and 18 in vegetated area

Plot B Bebb's willow (*Salix bebbiana)* stem cuttings
10 in cleared area and 10 in vegetated area

Plot C prickly rose (*Rosa accularis*) transplants
13 in cleared area and 12 in vegetated area

Plot D black spruce (*Picea mariana*) seedling transplants
11 in cleared area and 11 in vegetated area

Plot E Beauverd's spiraea (*Spiraea beauverdiana*) transplants
8 in cleared area and 6 in vegetated area

Plot F black spruce (*Picea mariana*) seeds
approximately 4 grams spread on each half of plot

Plot A	Plot B	Plot C	Plot D	Plot E	Plot F
Alaska birch	Bebb's willow	Prickly rose	Black spruce	Beauverd's spiraea	Black spruce
Transplants	Stem cuttings	Transplants	Seedling transplants	Transplants	Seeds

Comparison plot in undisturbed, forested area:

trees	*Picea mariana*	40%
	Betula neoalaskana	2%
shrubs	*Vaccinium vitus-idaea*	40%
	Betula glandulosa	< 1%
	Rosa acicularis	< 1%
	Spiraea beauverdiana	< 1%
	Ledum groenlandicum	< 1%
ground cover	*Pleurozium shreberi*	70%
	Nephroma arcticum	7%
	Cladina sp.	5%
	Cladonia sp.	5%

Site C-2 (Canadian Zone)

UTM Coordinates: **0634918 W** **7105576 N**
Elevation: 805 m
Slope: 35 ^{0}
Aspect: south

Soil Characteristics: well drained (moist at time of planting because of recent rains), fractured bedrock with clay, pH 6.5 on upper part with sparse growth and 7.0 on lower part with more dense growth

Reclamation History:
This area was recontoured, seeded and fertilized on October 8, 1997 with 75 kg/ha Brewery Creek seed mix and 300 kg/ha fertilizer (28-28-0). Seed and fertilizer were dispersed by a bulk mixer truck.

Brewery Creek seed mix included:
17% Fowl Bluegrass
16% Dalhurian Wild Rye
16% Sheep Fescue
16% Nugget Kentucky Bluegrass
12% Creeping Red Fescue
10% Climax Timothy
8% Noducoat Alsike Clover
5% Rangeland Alfalfa

Current Vegetation: In area of trial plot (seeded area)

shrubs	*Salix alaxensis*
forbs	*Crepis tectorum* *Medicago sativa* *Trifolium hybridum*
graminoids	*Bromus inermis* *Elymus trachycaulis* ssp. *subsecundus* *Festuca rubra* *Festuca ovina* *Hordeum jubatum* *Phleum pratense* *Poa palustris* *Poa pratensis*

Total vegetation cover: 60 % in area of dense growth
10 % in area of sparse growth

Shrub species used in reclamation trials:

Plot A black currant (*Ribes hudsonianum*) transplants
9 in cleared area and 6 in vegetated area

Plot B black spruce (*Picea mariana*) seeds
approximately 4 grams spread on each half of plot

Plot C raspberry (*Rubus idaeaus*) transplants
8 in cleared area and 7 in vegetated area

Plot D Alaska birch (*Betula neoalaskana*) transplants
10 in cleared area and 7 in vegetated area

Plot E trembling aspen (*Populus tremuloides*) transplants
10 in cleared area and 8 in vegetated area

Plot F little-tree willow (*Salix arbusculoides*) and blue-green willow (*Salix glauca*) stem cuttings
10 in cleared area and 10 in vegetated area

Plot A	Plot B	Plot C	Plot D	Plot E	Plot F
Black currant	Black spruce	Raspberry	Alaska birch	Trembling aspen	Little-tree willow and Blue-green willow
Transplants	Seeds	Transplants	Transplants	Transplants	Stem cuttings

Comparison plot in undisturbed, forested area:

trees	*Picea mariana*	25%
	Betula neoalaskana	7%
	Populus tremuloides	< 1%
shrubs	*Vaccinium vitus-idaea*	40%
ground cover	*Geocaulon lividum*	3%
	Pleurozium schreberi	10%
	Polytrichum sp.	3%
	Cladina sp.	1%
	Peltigera sp.	1%

Site LP-1 (below Leach Pad)

UTM Coordinates: 0632322 W 7104167 N
Elevation: 769 m
Slope: 8 ^{0}
Aspect: northwest
Soil Characteristics: moderately drained (moist at time of planting because of recent rains), fractured bedrock with clay, pH 6.5

Reclamation History:
This area was recontoured, seeded and fertilized on October 7, 1996 with 80 kg/ha Klondike Valley seed mix and 300 kg/ha fertilizer (18-18-18). Seed and fertilizer were dispersed by an ATV-mounted broadcaster.

Klondike Valley seed mix included:

25% Creeping Red Fescue
25% Common Bromegrass
15% Common Kentucky Bluegrass
10% Meadow Foxtail
10% Engmo Timothy
10% Alsike Clover
5% Red Top Bent Grass

Current Vegetation: In area of trial plot (seeded area)

shrubs	*Populus tremuloides*
	Salix arbusculoides
	Salix glauca
forbs	*Epilobium angustifolium*
	Equisetum arvense
	Trifolium hybridum
graminoids	*Agrostis gigantea*
	Bromis inermis
	Festuca rubra
	Phleum pratense

Total vegetation cover: 60%

Shrub species used in reclamation trials:

Plot A trembling aspen (*Populus tremuloides*) root cuttings
11 in cleared area and 11 in vegetated area

Plot B blue-green willow (*Salix glauca)* stem cuttings
10 in cleared area and 10 in vegetated area

Plot C prickly rose (*Rosa acularis*) transplants
10 in cleared area and 11 in vegetated area

Plot D Bebb's willow (*Salix bebbiana*) and little-tree willow (*Salix arbusculoides*) stem cuttings
8 in cleared area and 9 in vegetated area

Plot E dwarf birch (*Betula glandulosa*) transplants
7 in cleared area and 8 in vegetated area

Plot F black spruce (*Picea mariana*) seeds
approximately 4 grams spread on each half of plot

Plot A	Plot B	Plot C	Plot D	Plot E	Plot F
Trembling aspen	Blue-green willow	Prickly rose	Bebb's willow and Little-tree willow	Dwarf birch	Black spruce
Root cuttings	Stem cuttings	Transplants	Stem cuttings	Transplants	Seeds

Comparison plot in undisturbed, forested area:

trees	*Picea mariana*	15%
shrubs	*Vaccinium vitus-idaea*	15%
	Salix glauca	4%
	Ledum groenlandicum	3%
	Betula glandulosa	2%
	Vaccinium uliginosum	< 1%
ground cover	*Pleurozium schreberi*	30%
	Carex sp.	5%
	Nephroma arcticum	3%
	Equisetum sp.	2%
	Calamagrostis canadensis	< 1%
	Petasites sp.	< 1%

4.0 2001 Results and Analysis

The preliminary assessment of the potential of these shrub species for mine reclamation is based on the findings of two follow-up site visits during the summer of 2001.

4.1 2001 Monitoring Results

The results of the monitoring survey on July 3, 2001 are as follows:

Site C-1 (Canadian Zone)

Plot	Species	Cleared Area			Vegetated Area		
		Number Planted	Number Surviving	Survival %	Number Planted	Number Surviving	Survival %
A	Alaska birch Transplants	15	15	100	18	16	89
B	Bebb's willow Stem cuttings	10	0	0	10	0	0
C	Prickly rose Transplants	13	13	100	12	9	75
D	Black spruce Transplants	11	11	100	11	11	100
E	Beauverd's spiraea Transplants	8	8	100	6	6	100
F	Black spruce Seeds	4 grams	—	—	4 grams	—	—

Site C-2 (Canadian Zone)

Plot	Species	Cleared Area			Vegetated Area		
		Number Planted	Number Surviving	Survival %	Number Planted	Number Surviving	Survival %
A	Black currant Transplants	9	8	89	6	5	83
B	Black spruce Seeds	4 grams	—	—	4 grams	—	—
C	Raspberry Transplants	8	8	100	7	7	100
D	Alaska birch Transplants	10	10	100	7	5	71
E	Trembling aspen Transplants	10	10	100	8	6	75
F	Little-tree & Bluegreen willow Stem cuttings	10	0	0	10	1	10

Site LP-1 (below Leach Pad)

Plot	Species	Cleared Area			Vegetated Area		
		Number Planted	Number Surviving	Survival %	Number Planted	Number Surviving	Survival %
A	Trembling aspen Root cuttings	11	5	45	11	1	9
B	Blue-green willow Stem cuttings	10	0	0	10	0	0
C	Prickly rose Transplants	10	8	80	11	3	27
D	Bebb's & Little-tree willow Stem cuttings	8	0	0	9	0	0
E	Dwarf birch transplants	7	5	71	8	3	38
F	Black spruce Seeds	4 grams	—	—	4 grams	—	—

The most significant observation during the follow-up survey in August, 2001, was the propagation of black spruce seeds. While no seedlings had been evident during the early July survey, a large number had emerged by August 21 at Site C-1, the north-facing site in the Canadian Zone. Most of these were noted in the cleared portion of the plot, although some were also evident in the vegetated area (see photographs – Appendix A). A few black spruce seedlings were also noted in the cleared portion of Site C-2, the south-facing site in the Canadian Zone. No black spruce seedlings were observed at Site LP-1, the near level site below the leach pad.

4.2 Preliminary Analysis

Most of the transplanted shrub species had a high survival rate, particularly on the two well-drained sites at the Canadian Zone. Alaska birch, rose, Beauverd's spiraea, raspberry, black spruce and trembling aspen all had 100% survival rates on well-drained sites where the existing vegetation was cleared.

The fairly dense cover of vegetation (mostly seeded grasses and legumes) that occurred at the three sites at the time that the trial plots were established appears to have impaired the survival of several shrub species. The survival of trembling aspen, rose, Alaska birch and dwarf birch was higher in the portion of the plots that were cleared of existing vegetation prior to shrub transplanting. This may mean that grass and legume species have been seeded too densely to allow the growth of these shrub species. Beauverd's spiraea, raspberry, black currant and black spruce, on the other hand, survived equally well on the vegetated and cleared portions of the plots.

Trembling aspen root cuttings did not do as well on the vegetated half of the plot (9% survival) as they did on the cleared half (45% survival) at Site LP-1. This may be the result of dense ground cover vegetation (seeded with grasses and legumes) restricting the survival of the root cuttings. It was noted, however, that trembling aspens have begun to voluntarily colonize this seeded area.

The willow stem cuttings did not appear to survive well on any of the three plots. Another year's monitoring is required to confirm this, however, as stem cuttings exhibit shock, and full recovery does not usually occur until after the first growing season. The first year's energy is expended on the production of new root systems, and above-ground growth may not be evident until the second growing season. It should be noted that, although the winter snowpack at the Brewery Creek Mine was approximately normal, precipitation in June 2001 (a critical time for the propagation of stem and root cuttings at this latitude) was only 17.7 mm, compared to the normal precipitation of 38.8 mm for this area. It is generally recognized that the establishment of willow cuttings is most successful when carried out in early spring. In this project, however, funding and approval constraints made a fall planting necessary.

Black spruce seedlings had begun to emerge in late August at the two Canadian Zone sites, most notably at C-1, the north-facing site. This would be expected as black spruce typically occur on north-facing slopes (as well as on poorly-drained sites and in areas with permafrost)

5.0 Recommendations

Conclusive evidence as to the success (or failure) of the propagation of these shrub species can only be gained through continued surveillance. It is anticipated that several years' monitoring would be required for an accurate assessment of the reclamation potential for each shrub species. Survival rate is only the first measure of the reclamation potential of these species; their ability to propagate, either by seed or vegetatively, and colonize the remaining disturbed surfaces is equally important. From the first year's observations, however, the following judgements can be made:

- Some of the grass and legume species used to establish the initial vegetative cover at these reclaimed surfaces, or their application rates, may not be conducive to encouraging the next seral stages of vegetative succession. It should be noted again, however, that willows and aspens have begun to voluntarily colonize some of these seeded areas, although not uniformly.

- The low shrubs (raspberry, rose, black currant, spiraea and dwarf birch) transplanted at the mine site are showing high survival rates, particularly where existing ground vegetation is not too dense.

- Alaskan birch and trembling aspen transplants are also surviving well. As these trees are very common in this area, they may be good candidate species for the assisted revegetation of the large open areas at this mine site.

- The propagation of black spruce from seeds may be an effective way of revegetating colder sites (north-facing slopes and sites with permafrost). Seed cones should be collected from nearby areas, where possible. Black spruce transplants are also showing a high rate of survival.

It should be emphasized that the establishment of woody species, by transplanting or by the planting of dormant cuttings, is very time-consuming. The entire planting of large areas using these methods would, therefore, be prohibitively expensive. The spacing of small patches or 'islands" of shrubs throughout open areas so they can propagate and spread may, however, prove to be a feasible land reclamation technique.

References

Access Mining Consultants. 1999. **Vegetation Characteristics – Bohemian and Big Rock Ore Zones, Brewery Creek Mine**. Prepared for Viceroy Minerals Corporation.

Polster, D. F. 1991. **Natural Vegetation Succession and Sustainable Reclamation**. Paper presented to the Canadian Land Reclamation Association / B.C. Technical Research Committee on Reclamation Meeting. Kamloops B.C.

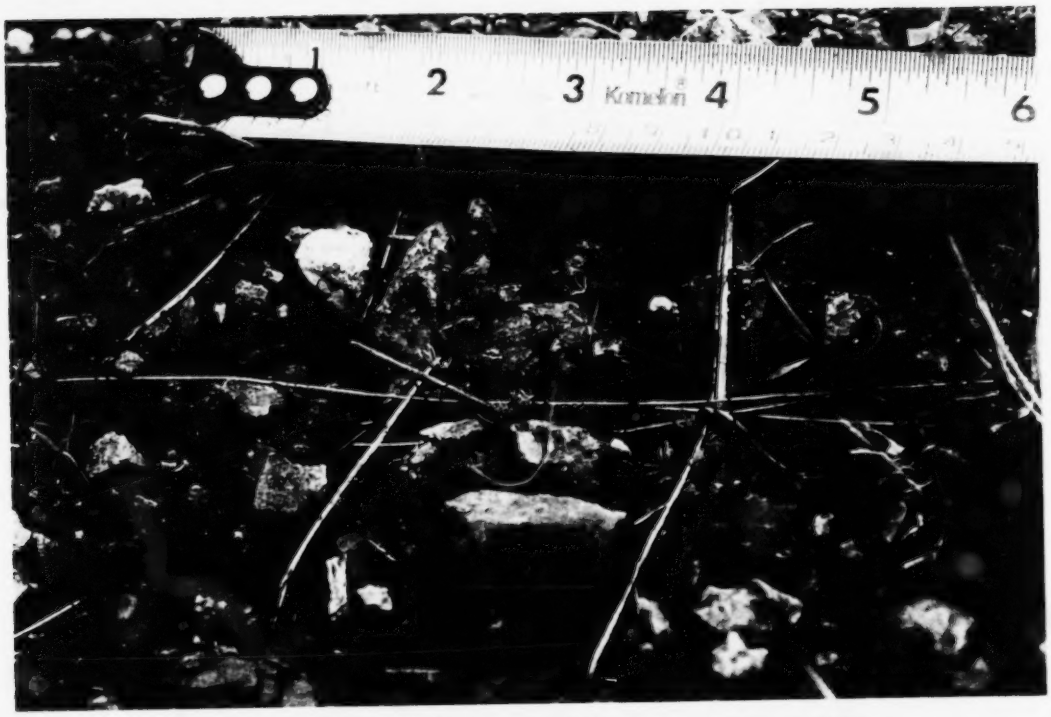
Viceroy Minerals Corporation. 1996–99. **Annual Water License Reports**. Submitted to Yukon Territory Water Board.

Appendix A: Photographs

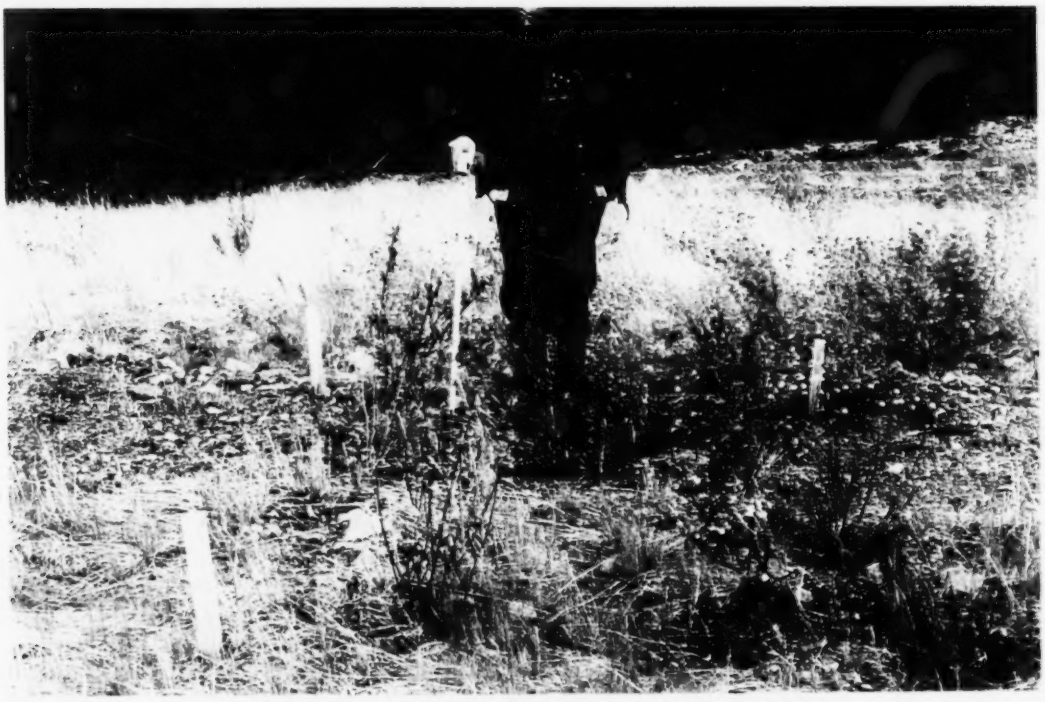
Site LP-1 (below leach pad) prior to shrub transplanting – July 2000

Site C-1 with grasses removed from half of plots – September 2000

Transplanting shrubs on Site C-1 – September 2000



Black spruce seedlings on Site C-1 – August 2001



Spiraea transplants on Site C-1 – August 2001

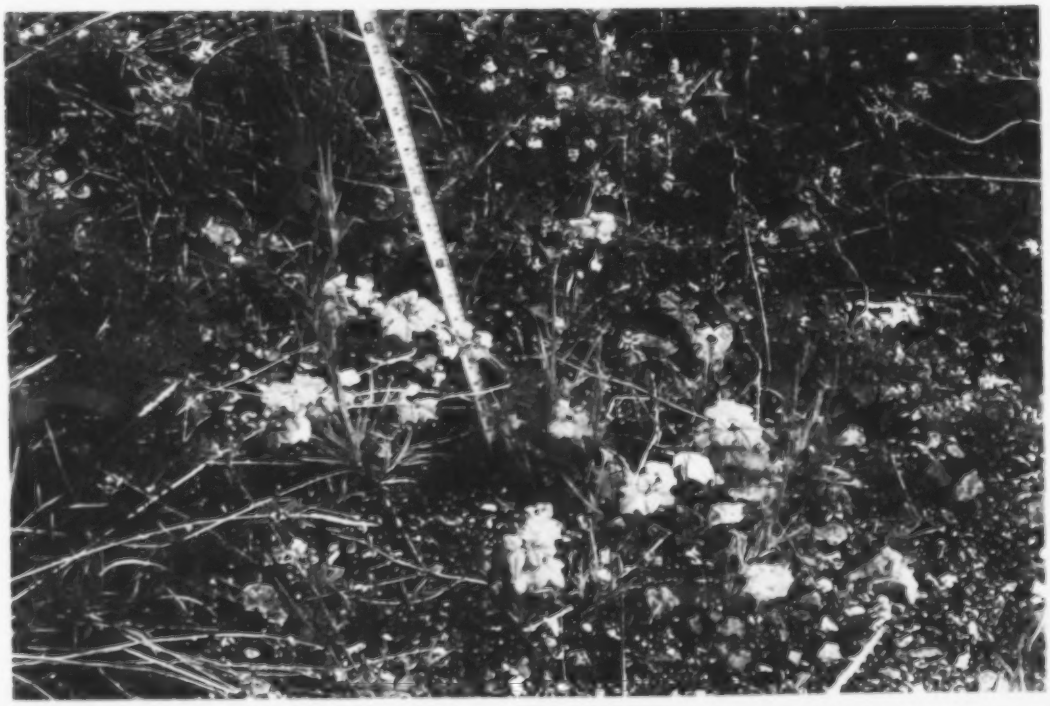
Black spruce transplant
on Site C-1 - July 2001

Trembling aspen transplant
on Site C-2 – July 2001

Spiraea transplants on Site C-1
July 2001

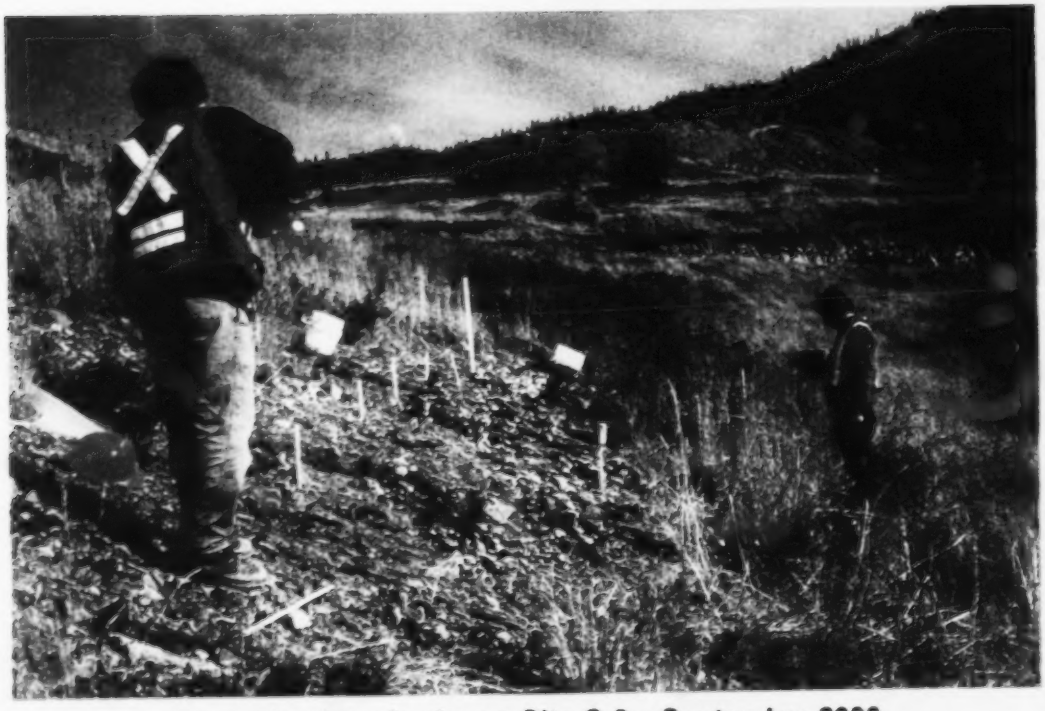
Alaska birch transplant
on Site C-1 - July 2001

Alaska birch transplants on Site C-2 – July 2001



Black currant transplants on Site C-2 – August 2001

Transplanting shrubs on Site C-2 – September 2000



Transplanting shrubs on Site C-2 – September 2000

Willows growing from stem cuttings on Site C-2 – August 2001

Raspberry shrub donor site – July 2000

Site LP-1 before transplanting – September 2000
(note aspens already colonizing area)

Rose transplants on Site LP-1 – August 2001

Aspen growing from
root cutting on
Site LP-1 - July 2001

Dwarf birch transplants
growing in clover on
Site LP-1 - August 2001

Yukon
Energy, Mines and Resources
Énergie, Mines et Ressources

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

ISBN 1-55362-062-3